

## State of the Ecosystem

Populations of *Diporeia* have been observed to decline shortly after zebra mussels become established. *Diporeia* are currently declining in portions of Lake Michigan, Lake Ontario, and eastern Lake Erie (see the figure with the *Hexagenia* indicator report - page 29). Areas where *Diporeia* are known to be rare or absent include the southeastern portion of Lake Michigan from Chicago to Grand Haven at water depths < 70 metres, all of Lake Ontario at depths < 70 metres except for some areas along the northern shoreline, and all of the eastern basin of Lake Erie. In other areas of Lakes Michigan and Ontario, *Diporeia* are still present, but abundances have decreased by one-half or more. Populations appear to be stable in Lake Superior. Recent evidence suggests that the reason for the decline of *Diporeia* may be related to the infestation of zebra mussels.

## Future Pressures

Expansion of zebra and quagga mussel populations at water depths of 30-50 metres will pose a threat to *Diporeia*.

## Acknowledgments

Author: Thomas Nalepa, National Oceanic and Atmospheric Administration, GLERL, Ann Arbor, MI.

## Deformities, Eroded Fins, Lesions and Tumours (DELT) in Nearshore Fish

**Assessment:** Poor

### Purpose

This indicator assesses the prevalence of external anomalies in nearshore fish. It will be used to infer areas where fish are exposed to contaminated sediments within the Great Lakes.

### Editor's Note:

The DELT Index (deformities, eroded fins, lesions, and tumours) was developed as a measure for the Index of Biological Integrity (IBI), and it has been included as one of the SOLEC indicators. Although the DELT index

looks at the entire fish community, its inclusion of all species and age groups lessens its discriminatory power in distinguishing amongst levels of contaminant exposure of fish from various tributaries.

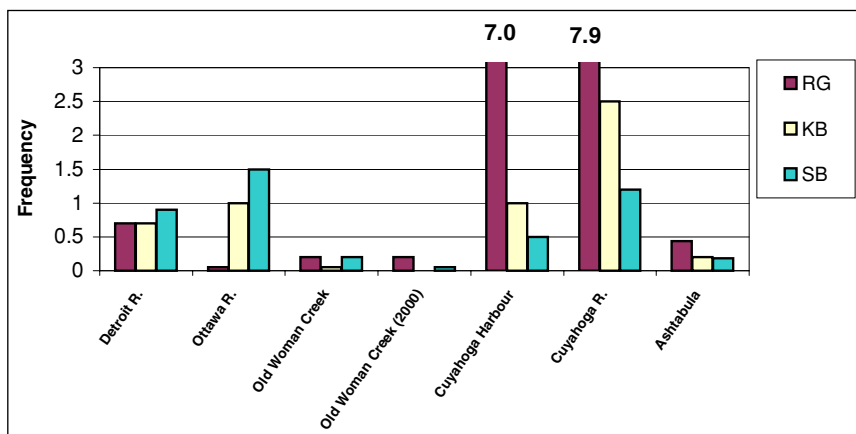
As an alternative indicator, the ELF Index (external lesion frequency) is being developed as an estimate of contaminant exposure of mature fish in a single species. Brown bullhead have been used to develop the index, since they are the most frequently used benthic indicator species in the southern Great Lakes. Information is included here to assist an evaluation of ELF as a SOLEC indicator.

## State of the Ecosystem

Field and laboratory studies have correlated chemical carcinogens found in sediments at some Areas of Concern in Lakes Erie, Michigan, and Huron with an elevated incidence of liver and external tumours. Other external anomalies may also be related to exposure to toxic chemicals, but their use must be carefully evaluated.

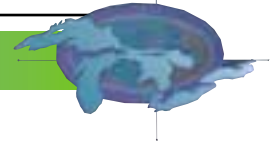
The most common external anomalies found in bullhead over the last twenty years are raised growths (RG) on the body or lips (often called tumours), focal discoloration (called melanistic spots), and stubbed or shortened/missing barbels (SB). Knobbed barbels (KB) have not been as consistently reported in the historical database, but also appear to be a useful parameter.

Preliminary findings from bullhead populations in several Lake Erie contaminated tributaries and a



External lesion frequency for brown bullheads in Lake Erie, 1999-2000. RG-raised growth, KB-knobbed barbels, SB-stubbed barbels.

Source: Lake Erie Ecological Investigation, unpublished. P. Baumann, U.S. Geological Survey, and D. Peterson, Ohio State University



reference site indicate that single anomalies occurring at  $> 0.4$  per fish or multiple anomalies occurring at greater than 0.8 per fish would indicate possible impairment.

#### Future Pressures

Continued exposure of the fish populations to contaminated sediments could cause deformities to persist.

#### Acknowledgments

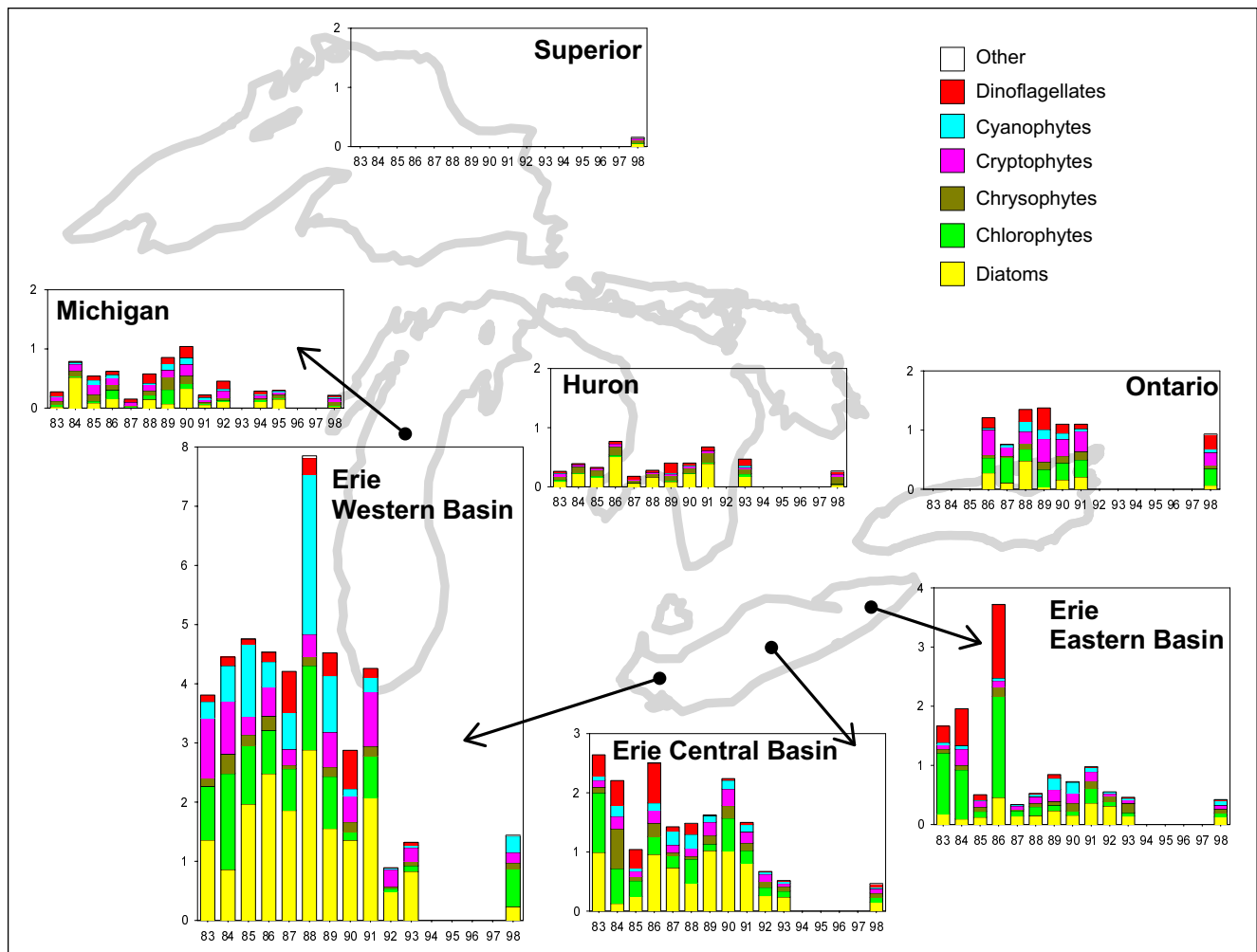
Authors: Stephen B. Smith, U.S. Geological Survey, Biological Resources Division, Reston, VA, and Paul C. Baumann, U.S. Geological Survey, Biological Resources Division, Columbus, OH.

### Phytoplankton Populations

**Assessment:** Unable to assess status until targets are determined

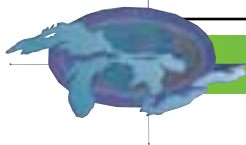
#### Purpose

This indicator involves the direct measurement of phytoplankton species composition, biomass, and primary productivity in the Great Lakes, and indirectly assesses the impact of nutrient/contaminant enrichment and invasive non-native predators on the microbial food-web of the Great Lakes.



Phytoplankton biovolume ( $\text{gm}/\text{m}^3$ ) and community comparison in the Great Lakes 1983-1998 (summer, open lake, epilimnion or upper waters). Blank indicates no data.

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office



## State of the Ecosystem

Substantial reductions in summer phytoplankton populations occurred in the late 1980s in the eastern basin of Lake Erie and in the early 1990s for the central and western basins. The data were highly variable year-to-year, so possible changes in community composition were not determined. In general, phytoplankton biomass in Lake Michigan was lower in the 1990s than in the 1980s. The timing of these declines in phytoplankton biomass suggest the possible impact of zebra mussels. No trends are apparent in phytoplankton biomass in Lakes Huron or Ontario.

## Future Pressures

Pressures on phytoplankton include changes in nutrient loadings; continued introductions and/or expansions of non-native species.

## Acknowledgments

Authors: Richard P. Barbiero, DynCorp I&ET, Alexandria, VA, and Marc L. Tuchman, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

## Phosphorus Concentrations and Loadings

### Assessment: Mixed

#### Purpose

This indicator assesses total phosphorus levels in the Great Lakes, and it is used to support the evaluation of trophic status and food web dynamics in the Great Lakes. Phosphorus is an essential element for all organisms and is often the limiting factor for aquatic plant growth in the Great Lakes.

#### State of the Ecosystem

Strong efforts begun in the 1970s to reduce phosphorus loadings have been successful in maintaining or reducing nutrient concentrations in the Lakes, although high concentrations still occur locally in some embayments and harbours.

Average concentrations in the open waters of Lakes Superior, Michigan, Huron, and Ontario are at or below guideline levels. Concentrations in all three basins of Lake Erie exceed phosphorus guidelines and recent data suggest an increasing trend, however, this may be an effect of large populations

of non-native zebra and quagga mussels. Further research is necessary. In Lakes Ontario and Huron, almost all offshore waters meet the desired guideline although some nearshore areas and embayments showed elevated levels which could promote nuisance algae growths such as the attached green algae, *Cladophora*.

## Future Pressures

Current control measures may no longer be sufficient because increasing numbers of people living along the Lakes will exert increasing demands on existing sewage treatment facilities, and additional loadings can be expected.

## Acknowledgments

Authors: Scott Painter, Environment Canada, Environmental Conservation Branch, Burlington, ON, and Glenn Warren, U.S. Environmental Protection Agency, Great Lakes National Programs Office, Chicago, IL.

## Contaminants in Colonial Nesting Waterbirds

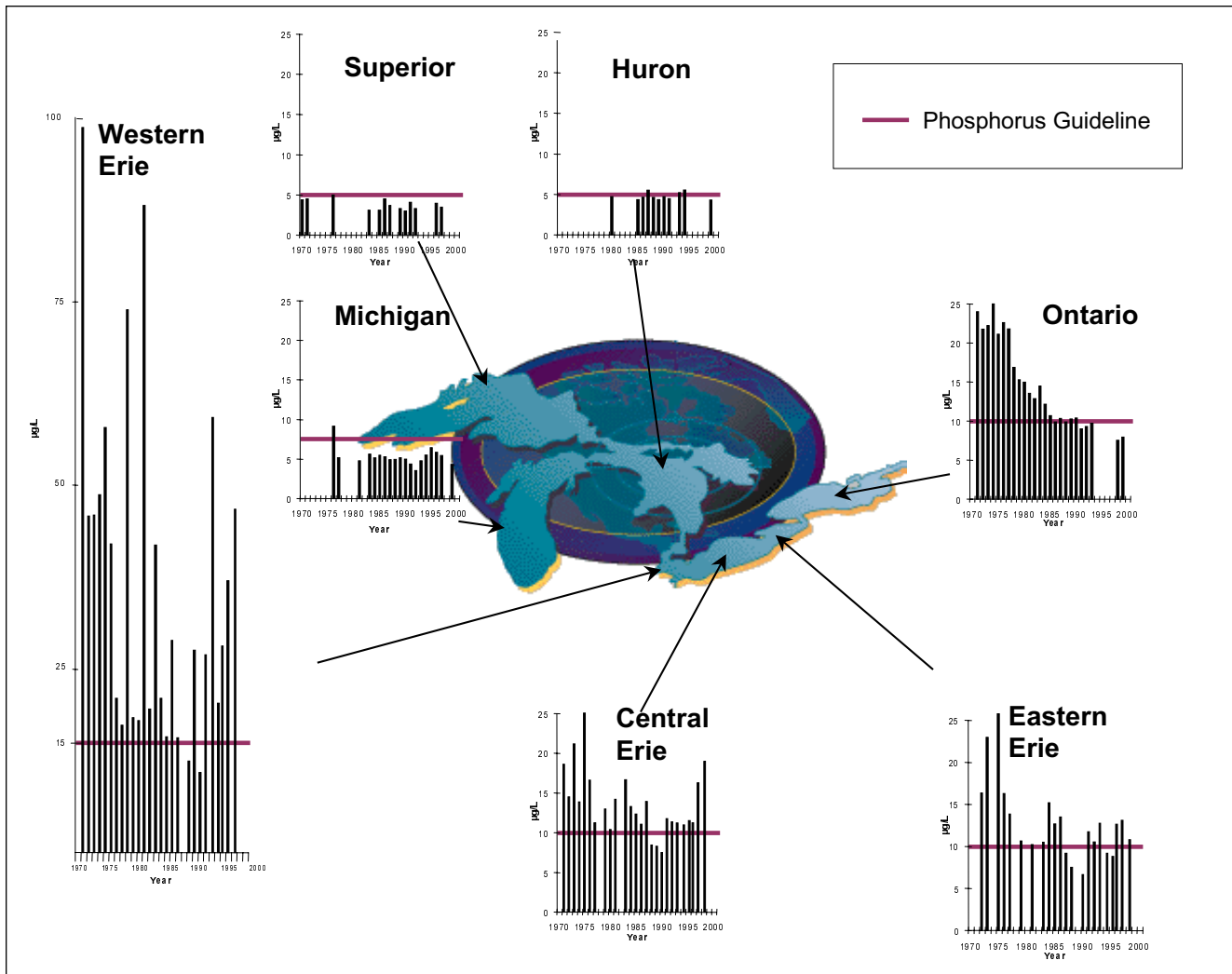
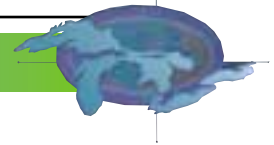
### Assessment: Good

#### Purpose

This indicator assesses current chemical concentration levels and trends as well as ecological and physiological endpoints in representative colonial waterbirds (gulls, terns, cormorants and/or herons). These features will be used to infer the impact of contaminants on the health of the waterbird populations.

#### State of the Ecosystem

Most contaminants in herring gull eggs have declined by a minimum of 50% and many have declined more than 90% since monitoring began in 1974. As well, the rate of decline in more than 70% of cases is as fast or faster than in the past. Gull eggs from Lake Ontario and the St. Lawrence River continue to have the greatest levels of mirex and dioxin (2,3,7,8 TCDD), those from the upper lakes have the greatest levels of dieldrin and heptachlor epoxide, those from Lake Michigan have the greatest levels of DDE and those from Lake Michigan and the Detroit River-Western Lake Erie area have the greatest levels of PCBs.



Total phosphorus trends in the Great Lakes 1971-2000 (spring, open lake, surface). Blank indicates no sampling.

Source: Environmental Conservation Branch, Environment Canada and U.S. Environmental Protection Agency, Great Lakes National Program Office

Populations of most species have increased over those of 25-30 years ago. Interestingly, Double-crested Cormorants, whose population levels have increased more than 400-fold, still exhibit some eggshell thinning.

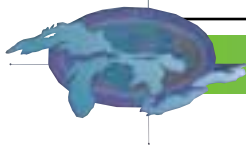
#### Future Pressures

All contaminants entering the Great Lakes including those from re-suspension of contaminated sediments, atmospheric inputs, and underground leaks from landfill sites, will continue to put pressure on colonial nesting waterbirds.

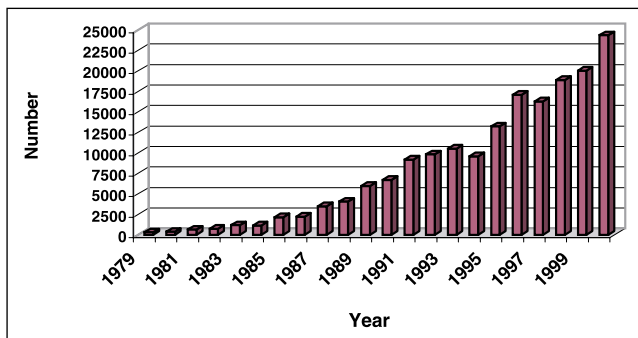
#### Acknowledgments

Author: D.V. Chip Weseloh, Canadian Wildlife Service, Environment Canada, Downsview, ON.

Thanks to other past and present staff at CWS-Ontario Region (Burlington and Downsview), as well as staff at the CWS National Wildlife Research Centre (Hull, Que.) and wildlife biologists Ray Faber, Ralph Morris, Jim Quinn, John Ryder, Brian Ratcliff and Keith Grasman for egg collections, preparation, analysis and data management over the 27 years of this project.

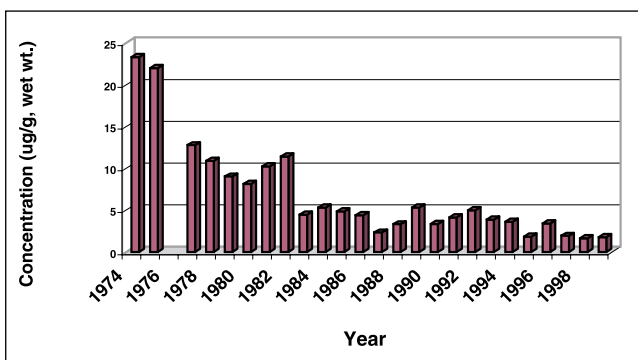


# STATE OF THE GREAT LAKES 2001



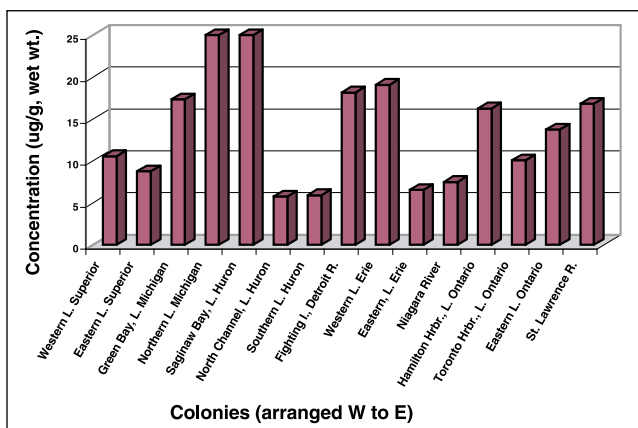
Double-crested Cormorant nests (breeding pairs) in Lake Ontario (1979-2000). Temporal trends.

Source: C. Pekarik and D.V. Weseloh, Canadian Wildlife Service, unpublished



DDE in Herring Gull eggs, Toronto Harbour 1974-1999. Spatial trends.

Source: C. Pekarik and D.V. Weseloh, Canadian Wildlife Service, unpublished



PCBs in Great Lakes Herring Gull eggs, 1999. Population trends.

Source: Canadian Wildlife Service, unpublished

## Zooplankton Populations

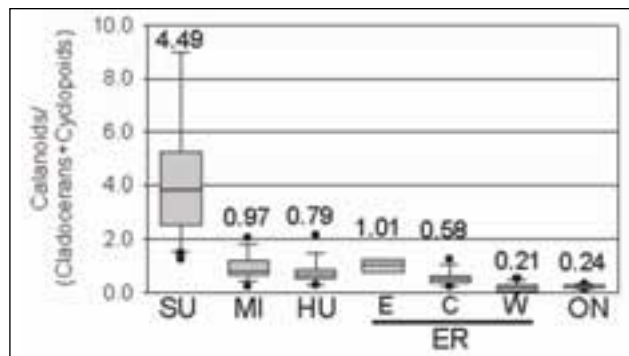
**Assessment:** Unable to assess status until targets are determined

### Purpose

This indicator directly measures changes in community composition, mean individual size and biomass of zooplankton populations in the Great Lakes basin, and indirectly measures changes in food-web dynamics due to changes in vertebrate or invertebrate predation.

### State of the Ecosystem

This indicator should provide information on the biological integrity of the Great Lakes. However, since specific targets or endpoints for this indicator have yet to be identified, it will be hard to determine whether conditions are improving or deteriorating.

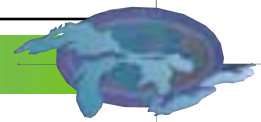


Ratio of biomass of calanoid copepods to that of cladocerans and cyclopoid copepods for the five Great Lakes. Lake Erie is divided into western, central and eastern basins.

(Data collected with 153  $\mu$ m mesh net tows to a depth of 100 metres or the bottom of the water column, whichever was shallower. Numbers indicate arithmetic averages.)

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office (1998)

The ratio of calanoids to cladocerans and cyclopoids (different groups of zooplankton) showed a clear relationship with trophic state of the waters. The average value for the oligotrophic (low nutrient levels) Lake Superior was at least four times as high as that for any other lake, while Lakes Michigan and Huron and the eastern basin of Lake Erie were also



high. The western basin of Lake Erie and Lake Ontario were both low, while the central basin of Lake Erie had an intermediate value. In the western and central basins of Lake Erie, a significant increase in the ratio of calanoids to cladocerans and cyclopoids was observed between 1970 and 1983-1987, and this increase was sustained throughout the 1990s.

#### Future Pressures

Zooplankton populations will continue to be affected by invasive non-native species, e.g., the spiny water flea and the fishhook water flea, and continued proliferation of zebra and quagga mussel populations.

#### Acknowledgments

Authors: Richard P. Barbiero, DynCorp I&ET, Alexandria, VA, Marc L. Tuchman, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago IL, and Ora Johannsson, Fisheries and Oceans Canada, Burlington, ON.

## Atmospheric Deposition of Toxic Chemicals

**Assessment:** Mixed, improving

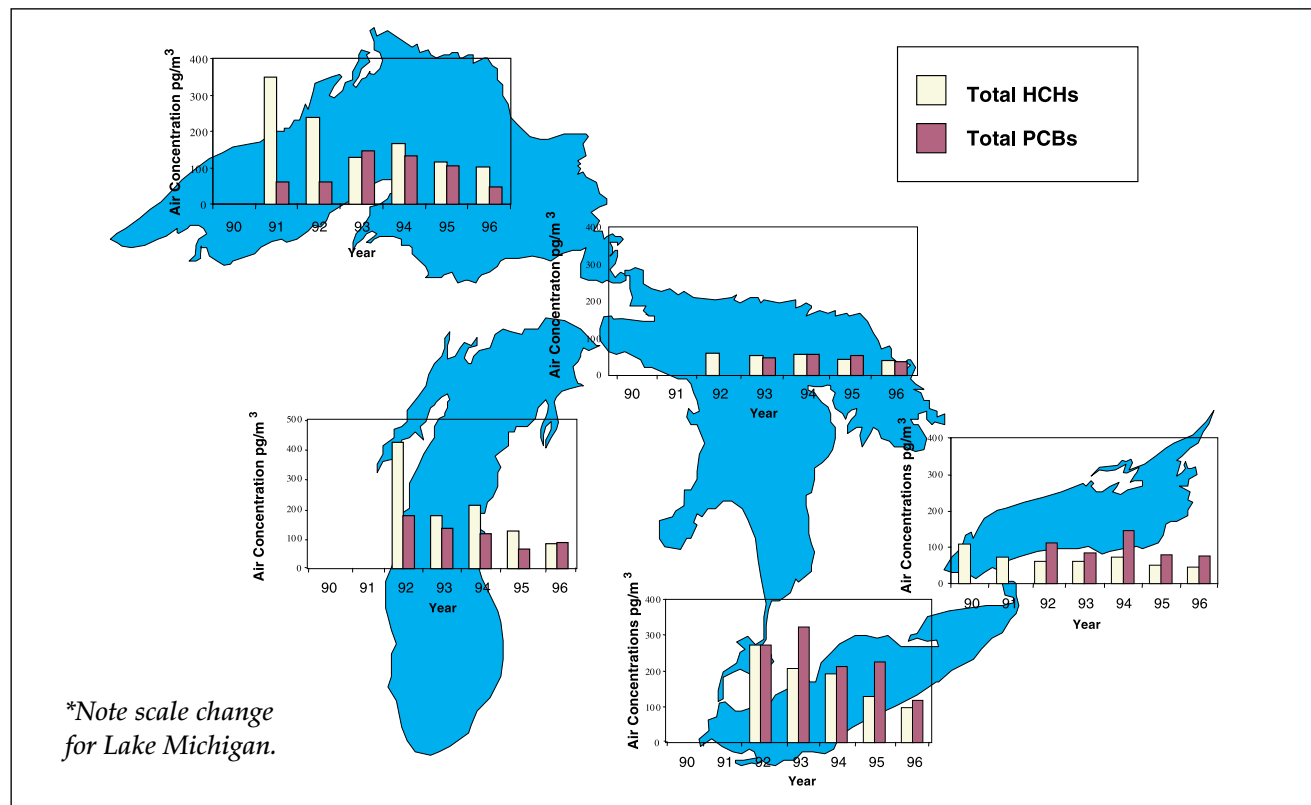
#### Purpose

This indicator estimates the annual average loadings of priority toxic chemicals from the atmosphere to the Great Lakes, and it is used to determine temporal trends in contaminant concentrations.

#### State of the Ecosystem

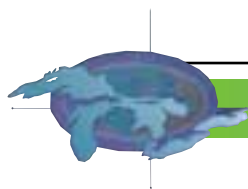
The Integrated Atmospheric Deposition Network (IADN) consists of five master sampling sites, one near each of the Great Lakes, and several satellite stations. The data set is large, and only selected data are presented here.

For gas-phase total PCBs (polychlorinated biphenyls), elevated concentrations were consistently observed at the Lake Erie site compared to the other Lakes. For all sites, the trend over time is generally



Atmospheric concentration of total PCB and total HCH.

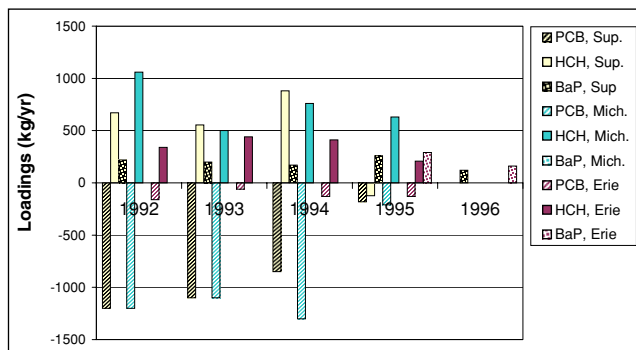
Source: Integrated Atmospheric Deposition Network Steering Committee (2000)



downward. Total PCB concentrations at a satellite site in downtown Chicago were about 10 times higher than at the more remote sites.

Gas-phase  $\alpha$ - and  $\gamma$ -HCH (hexachloro-cyclohexane) concentrations declined at all sites until 1996.  $\gamma$ -HCH (lindane) is a pesticide used as a seed treatment in the United States and Canada, and atmospheric concentrations may not decrease further.

The loadings from the atmosphere to the Great Lakes for total PCB, HCH, and BaP (Benzo[*a*]pyrene) are displayed in the accompanying figure. A negative bar indicates that the lake is vaporizing the compound to the atmosphere. A missing bar indicates that the loading could not be calculated, not that the loading was zero. These data show that the loadings are generally getting smaller and the lake water and the air above it are getting closer to being in equilibrium.



Loadings of Total PCBs, Total HCHs, and BaP to the Great Lakes.

Source: Integrated Atmospheric Deposition Network Steering Committee (2000)

### Future Pressures

Atmospheric loadings of toxic compounds are likely to continue well into the future.

### Acknowledgments

Ron Hites and Ilora Basu at Indiana University prepared this report on behalf of the IADN Steering Committee.

## Toxic Chemical Concentrations in Offshore Waters

### Assessment: Mixed

#### Purpose

This indicator reports the concentration of toxic chemicals in offshore waters, and it infers the potential for impacts on the health of the Great Lakes aquatic ecosystem.

#### State of the Ecosystem

Many toxic chemicals are present in the Great Lakes. Examples of only a few illustrate spatial and temporal trends from a single source of information.

Organochlorine pesticides such as lindane and dieldrin are observed at relatively similar concentrations in all lakes and connecting channels. Concentrations decreased by approximately 50% between 1986 and 1996, but dieldrin still far exceeds the most sensitive water quality criterion for the protection of human consumers of fish.

Hexachlorobenzene (HCB), octachlorostyrene, and mirex are chemicals whose presence is due to historical localized sources. Concentrations of all three in the Niagara River have decreased by more than 50% between 1986 and 1996. However, both HCB and mirex continue to exceed the most stringent criteria for the protection of human consumers of fish.

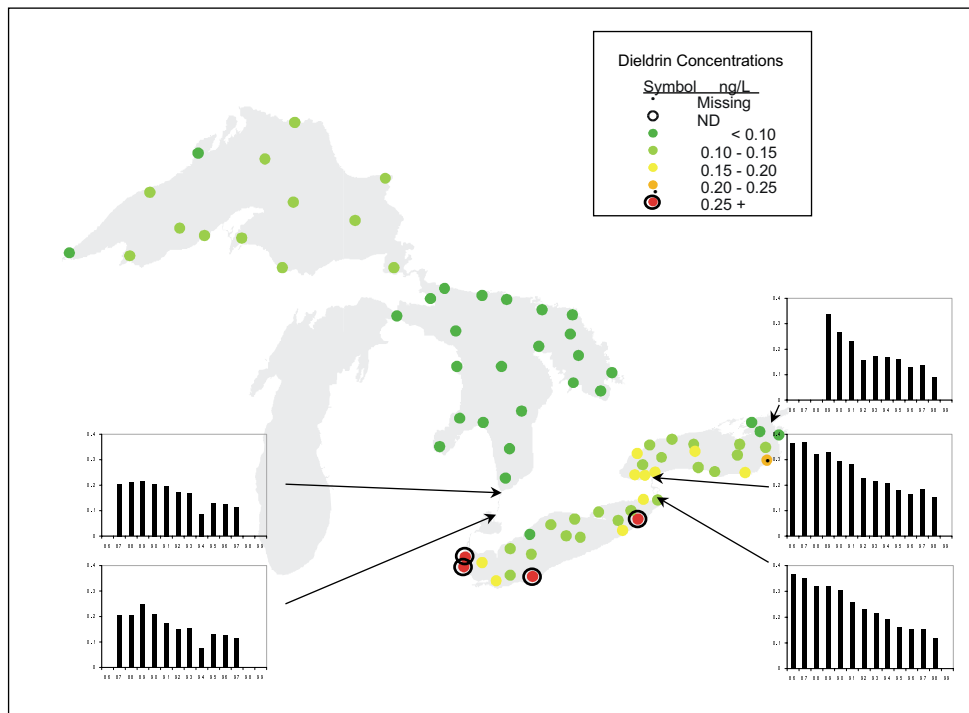
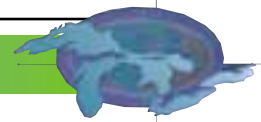
Concentrations of some (not all) polycyclic aromatic hydrocarbons (PAHs) appear to be increasing, suggesting localized sources. For example, comparisons of upstream/downstream concentrations of fluoranthene over time suggest increasing inputs from localized sources in the Niagara River.

#### Future Pressures

Active sources for some chemicals still exist; classes of chemicals such as endocrine disrupting chemicals, in-use pesticides, and pharmaceuticals are emerging issues.

### Acknowledgments

Author: Scott Painter, Environment Canada, Environmental Conservation Branch, Burlington, ON.

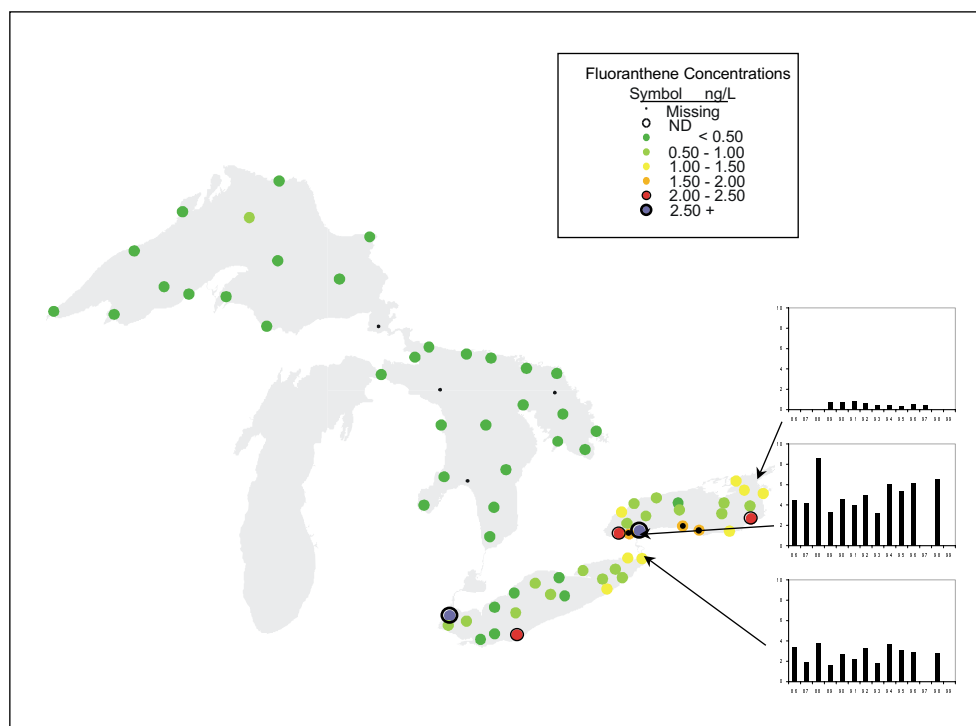


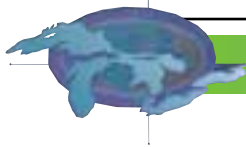
Spatial dieldrin patterns in the Great Lakes (spring 1997 or 1998, surface) and annual most likely estimated averages for the interconnecting channels from 1986 to 1998. Units = ng/L

Source: Environmental Conservation Branch, Environment Canada

Spatial fluoranthene patterns in the Great Lakes (spring 1997 or 1998, surface) and annual most likely estimated averages for the interconnecting channels from 1986 to 1998. Units = ng/L

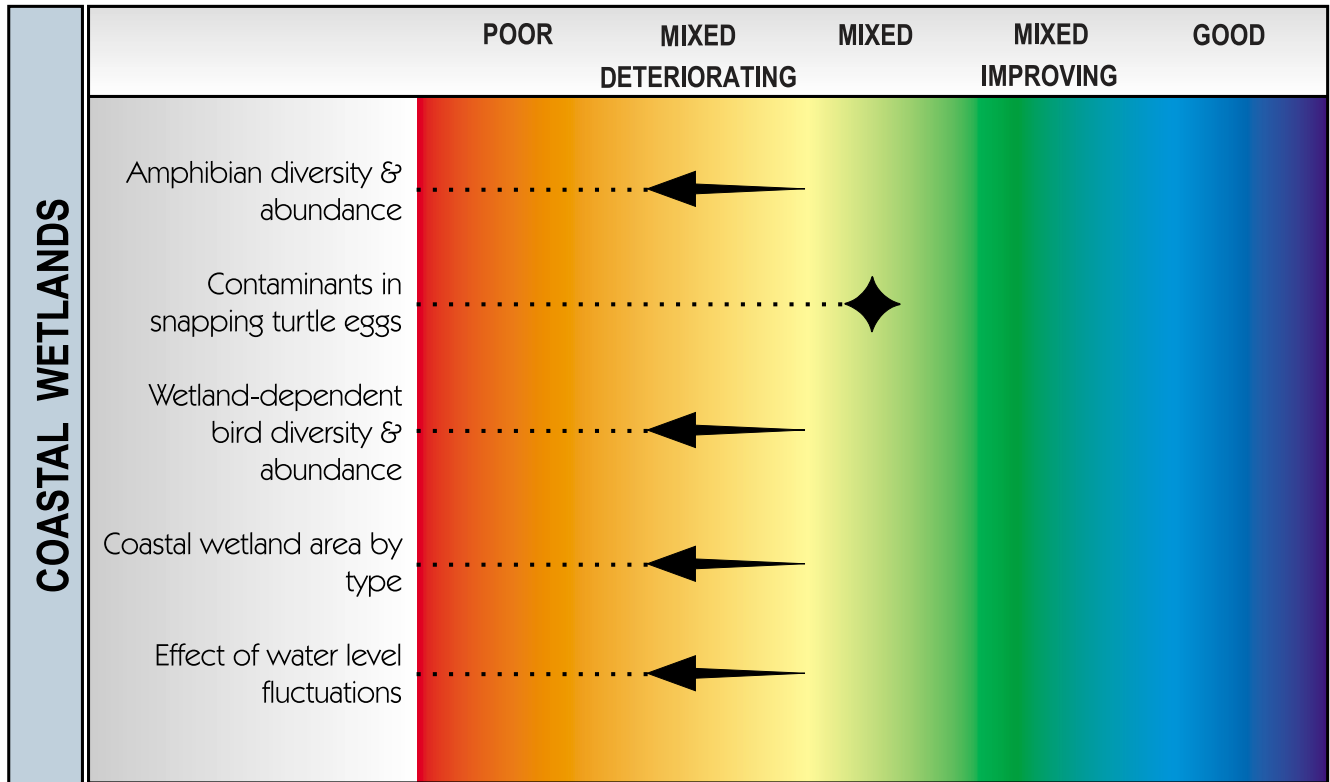
Source: Environmental Conservation Branch, Environment Canada





## 3.2 Coastal Wetlands

### Coastal Wetland Indicators - Assessment at a Glance



#### Amphibian Diversity and Abundance

**Assessment:** Mixed, deteriorating

##### Purpose

Assessments of the species composition and relative abundance of calling frogs and toads are used to help infer the condition of Great Lakes basin marshes (i.e. wetlands dominated by non-woody emergent plants).

##### State of the Ecosystem

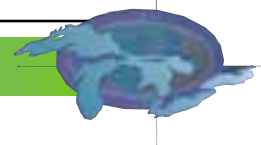
With only five years of data collected across the Great Lakes basin, the Marsh Monitoring Program (MMP) is quite new as a monitoring program. From 1995 through 1999, 11 frog and two toad species were recorded by MMP participants surveying 354

routes across the Great Lakes basin. Spring Peeper was the most frequently detected species. Green Frog was detected in more than half of station years. Gray Treefrog, American Toad and Northern Leopard Frog were also common.

Although some trends were suggested for species such as American Toad and Bullfrog, only the declining trend for Chorus Frog could be resolved with statistical confidence. Anecdotal and research evidence suggests that wide variations in the occurrence of many amphibian species at a given site is a natural and ongoing phenomenon.

##### Future Pressures

Threats to amphibians include habitat loss and deterioration, water level stabilization,



Species Name	% station-years present*	Average calling code
Spring Peeper	69	2.5
Green Frog	56.6	1.3
Gray Treefrog	37.9	1.9
American Toad	36.9	1.5
N. Leopard Frog	32.6	1.3
Bullfrog	26.6	1.3
Chorus Frog	25.3	1.7
Wood Frog	18.7	1.5
Pickerel Frog	2.4	1.1
Fowler's Frog	1.4	1.2
Mink Frog	1.3	1.2
Blanchard's Cricket Frog	0.9	1.2
Cope's Gray Treefrog	0.9	1.3

\* MMP Survey stations monitored for multiple years considered as individual samples.

Frequency of occurrence and average Call Level Code for amphibian species detected inside Great Lakes basin MMP stations, 1995 through 1999. Average calling codes are based upon the three level call code standard for all MMP amphibian surveys; surveyors record Code 1 (little overlap among calls, numbers of individuals can be determined), Code 2 (some overlap, numbers can be estimated) or Code 3 (much overlap, too numerous to be estimated).

Source: Marsh Monitoring Program

sedimentation, contaminant and nutrient inputs, and invasion of non-native plants and animals.

## Acknowledgments

Author: Russ Weeber, Bird Studies Canada, Port Rowen, ON.

The Marsh Monitoring Program is delivered by Bird Studies Canada in partnership with Environment Canada's Canadian Wildlife Service and with significant support from the U.S. Environmental Protection Agency's Great Lakes National Program Office and Lake Erie Team. The contributions of all Marsh Monitoring Program staff and volunteers are gratefully acknowledged.

## Contaminants in Snapping Turtle Eggs

### Assessment: Mixed

#### Purpose

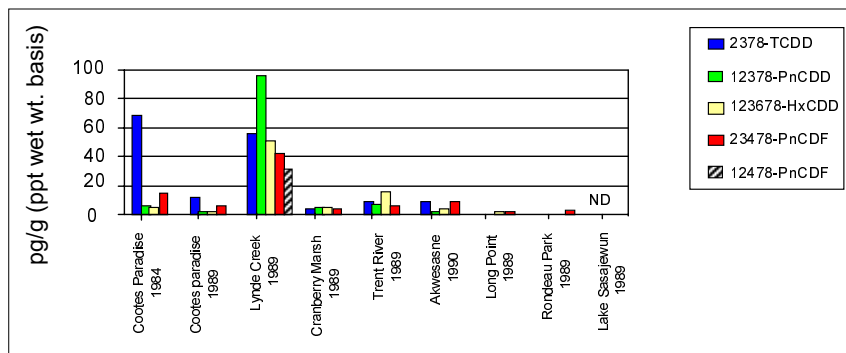
This indicator measures the concentrations of persistent contaminants in the eggs of common snapping turtles living in wetlands of the Great Lakes basin in order to provide an indirect measure of foodweb contamination and its effects on wetland wildlife.

#### State of the Ecosystem

Snapping turtle eggs collected at two Lake Ontario sites (Cootes Paradise and Lynde Creek) had the highest polychlorinated dioxins (PCDD) concentrations (notably 2,3,7,8-TCDD) and number of detectable furans (PCDF). Eggs from Cranberry Marsh (Lake Ontario) and two Lake Erie sites (Long Point and Rondeau Provincial Park) had similar levels of PCBs and organochlorines. Eggs from Akwesasne (St. Lawrence River) contained the highest level of PCBs relative to all other sites.

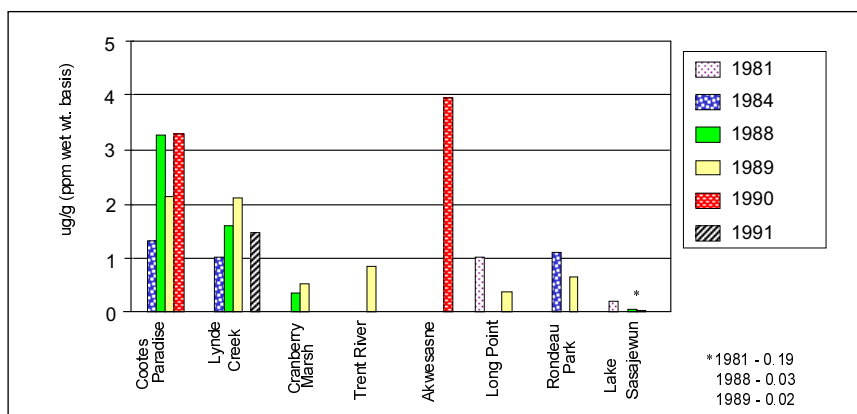
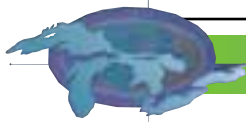
Levels of PCBs and DDE (not shown) increased significantly from 1984 to 1990/91 in eggs from Cootes Paradise and Lynde Creek, but levels of PCDDs (including 2,3,7,8-TCDD) and PCDFs decreased significantly at Cootes Paradise during this time.

Eggs with the highest contaminant levels also showed the poorest developmental success. Rates of abnormal development of snapping turtle eggs from (1986-1991) were highest at all four Lake Ontario sites compared to all other sites studied.



Dioxin and furan concentrations (1984; 1989/90) in snapping turtle eggs at Canadian Great Lakes study sites.

Source: C. Bishop, Canadian Wildlife Service



Mean sum PCB concentrations (1981-1991) in snapping turtle eggs at Canadian Great Lakes study sites and one inland reference site.

Source: C. Bishop, Canadian Wildlife Service

## Future Pressures

Snapping turtles in some Great Lakes locations will continue to be exposed to toxic chemicals through a diet of contaminated fish.

## Acknowledgments

Author: Kim Hughes, Canadian Wildlife Service, Environment Canada, Downsview, ON.

Contributions from Christine Bishop, Canadian Wildlife Service, Environment Canada, R.J. Brooks, University of Guelph, Canadian Wildlife Service - National Wildlife Research Centre and Peggy Ng, York University.

## Wetland-Dependent Bird Diversity and Abundance

**Assessment:** Mixed, deteriorating

## Purpose

Assessments of the diversity and abundance of wetland-dependent birds in the Great Lakes basin, combined with an analysis of habitat characteristics, are used to evaluate the health and function of wetlands.

## State of the Ecosystem

Although results are still preliminary, from 1995 through 1999, 53 species of birds that use marshes (wetlands dominated by non-woody emergent plants) for feeding, nesting or both were recorded by Marsh Monitoring Program (MMP) volunteers at 322 routes throughout the Great Lakes basin. Statistically significant basin-wide increases were observed for Canada Goose, Mallard, Chimney Swift, Northern Rough-winged Swallow, Common Yellowthroat and Common Grackle. Species with significant basin-wide declines were Pied-billed Grebe, Blue-winged Teal, American Coot, undifferentiated Common Moorhen/ American Coot, and Black Tern. Each of the declining species depends upon wetlands for breeding, but because they use wetland habitats almost exclusively, the Pied-billed Grebe, American Coot, Common Moorhen, and Black Tern are particularly dependent on the availability of healthy wetlands.